WELL Study

Review of Safety in Construction and Operation for the WS&S Sector - a literature review: Part II

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1. Introduction

Water and sanitation projects are frequently justified on the basis of their contribution to health. Those familiar with the sector know that the necessary facilities (e.g. treatment works, storage tanks, pumping stations and sewers) all involve significant occupational risks for those building and operating these facilities. Construction and operation in developing countries is particularly dangerous, and a cursory inspection of any job site will reveal many health and safety hazards.

The majority of the health and safety guidance from international organisations such as the International Labour Organisation (ILO) assumes the existence of powerful regulatory authorities, and therefore stresses an administrative approach to the problem. While these techniques have worked well in industrialised countries, they are inappropriate where regulation is weak or non-existent.

This project, *review of safety in construction and operation for WS&S sector,* has been undertaken by the WELL Resource Centre. This report provides a critical literature review of construction safety in developing countries, highlighting the most relevant and useful publications, and identifying possible areas for future work or research. It is accompanied by a brief summary note for policy makers and practitioners in the sector.

2. Literature review

Literature covering construction safety broadly falls into 4 categories.

- Accident statistics and causes of construction injuries or fatalities.
- On site accident prevention methods.
- The role of stakeholders, apart from contractors, in preventing accidents.
- Institutional aspects of construction safety.

There is very little literature relating directly to the safety on construction sites in developing countries. Existing publications tend to suggest how accidents may be prevented but assume that a strong regulatory body exists to enforce legislation. This literature review therefore presents information which is either specific to developing countries or has been prepared in a developed country context but would also be applicable to developing countries.

The construction industry is a labour intensive industry both in developed and developing countries, with a large number of tasks being undertaken in similar ways in both regions. It would therefore be reasonable to assume that accident statistics from the UK and other developed countries follow a similar pattern to the unknown statistics in developing countries**.**

2.1 Accident statistics

The construction industry is economically important as it typically contributes 10 per cent of a developing country's GNP. It is also very hazardous with almost six times as many fatalities and twice as many injuries per hour worked relative to a manufacturing industry. Helander (1991) analyses 739 construction fatalities that occurred in the UK. He found that fifty two per cent occurred due to falls from roofs, scaffolds and ladders. Falling objects and material were involved in 19.4 per cent of the deaths, and transportation equipment, (e.g. excavators and dumpers) were involved in 18.5 per cent. Helander also found that 5 per cent of construction accidents occur during excavation work.

The categories used for classifying fatal accidents were:

- Falls
- Falling material and objects
- Electrical hazards
- Transport and mobile plants
- Other

The majority of accidents that involved falls occur during work on roofs, scaffolds and ladders. Collapses of structures and falling materials also account for a large proportion of fatalities. Many of the safety hazards are specific to the different trades, and typically construction workers underestimate the hazards in their own work which affects the motivation for adopting safe work procedures. The establishment and use of procedures and regulations to enhance safety can avoid a large proportion of these accidents. There are also forceful monetary incentives in construction safety as it is estimated that construction accidents amount to about 6 per cent of total building costs; this should encourage the industry as well as the regulatory agencies to invest in construction safety.

A table in Helander's article also desegregated workers into supervisors and different classes of workers. Helander's article categorises the primary events as follows:

- Fall of person.
- Overexertion or strenuous movement.
- Handling accidents.
- Struck by falling or flying objects.
- Contact with stationary objects, missed steps, etc.
- Contact with moving objects.
- Contact with heat/ cold.
- Contact with chemicals.
- Exposure to or contact with electricity.
- Fire. Explosion or blast.
- Unclassified.

Based on a study of cases from UK, USA, France, Canada and Sweden the author also provided a comparison of construction and manufacturing for injury incidence rates both for different parts of the body and for different categories of the workers. Supervisors experienced a very high rate of falls injuries and the highest rate of accidents from stepping on objects. For plumbers the highest rate of accidents involved being ‘struck by falling or flying objects’ and for masons the highest rate was for ‘overexertion or strenuous movement’. The five most dangerous hand tools for all categories of workers were:

- Knife.
- Hammer, sledge hammer, etc.
- Grinding, cutting machine.
- Jackhammer.
- Drill.

Helander (1991) indicates top managers can contribute to reducing the number of accidents if they:

- note the safety records of all their field managers and give these figures the same importance as productivity and overall cost.
- communicate safety issues to staff along with cost and timing issues.
- develop mechanisms for allocation of safety costs.
- ensure through improved planning that equipment and materials required for safe working are available on site.
- train newly hired people in safety issues.
- make safety awards.
- ensure the effective use of safety departments.

He also recommended that safety should be used as a criterion in selecting the potential contractors.

The study is a good example of developing methodology for the practical use of statistical information. The study went into further detail on such questions as why workers do not use

helmets even in industrialised countries. Discomfort was cited as the main reason why workers are reluctant to wearthem. Unfortunately, comfort has not generally been considered important when designing and providing safely clothing and equipment.

In 1981, USA construction accidents were estimated to cost around six billion dollars in terms of insurance premiums and compensation. The insurance premium alone represents $2000 per worker employed. In addition to the other direct and indirect costs of accidents (such as time taken by the supervisors to report accidents), the damage or loss of material and reduced productivity was estimated to cost six times more than the cost of insurance. The combined cost of insurance premiums and other costs represent *around six percent of the total cost of construction work.*

Dedobbeleer and German (1987) evaluated the relationships between a worker's safety performance index and attitudinal factors related to safety. The authors considered three factors; reinforcing factors, enabling factors, and predisposing factors. Reinforcing factors measure the attitudes of other towards safety; enabling factors measure the availability of safety factors (e.g. safety equipment) at the work place; predisposing factors measure the knowledge and attitudes towards safety of the individual worker. Some other factors like demographic were also used for interaction. The predisposing factor alone explained most of the variation in safety performance. Most workers under 26 years of age had relatively low safety performance scores, relatively little knowledge about safety and an unfavourable attitude towards safety performance.

The study concluded that:

- falls are the most serious hazard.
- research on safety motivation shows that hazard recognition is an essential element.
- many accidents involve hand tools. Ergonomics can improve safety through better design.
- protective equipment needs to be comfortable.

The paper also dealt with the psychological aspects of safety, such as motivation and attitudes. It suggested a shift from the current practice of training which stresses the desirability of safety to a subtler approach which asks what methods are available to motivate and change attitudes of construction related personnel to improve safety.

The Health and Safety Executive (HSE,1985) reported that the maintenance of a plant or machines involved hazards not encountered during normal operations. There is a need to give attention to the health and safety issues related to operation and maintenance and not just to construction.

In a later study on maintenance, HSE (1988) reported that 21 per cent of fatal accidents belongs to the maintenance category. A high number of deaths were associated with plant and machinery maintenance, and roof work. The study was based on 326 fatal accidents in the UK. In the overall construction sector, a third of the annual death toll is classified under "maintenance works". There are therefore obviously significant health and safety risks associated with operation and maintenance.

Hinze (1978) explored the impact of new workers and turnover rate on safety. Hinze identified the following key factors:

- Superintendents having the same crew from the previous jobs had fewer injuries.
- Safety increases when the employer retains the worker for one year, and the benefits increase with longer continuous service.

Hinze and Parker (1978) investigated the characteristics of superintendents associated with improved safety. They found:

- injuries increased with job-related pressures.
- competition within or between crews supported by the superintendent led to more injuries.

Hinze and Francine (1979) explored the supervisor-worker relationship and how it affects the safety. They found that:

- a more flexible approach to conflict resolution improved safety records.
- safety performance is worse where the foreman has full firing authority.

Hinze, J., Pedersen, C., and Fredley, J. (1998) reported that OSHA (the U.S. Occupational Safety and Health Administration) is a useful source of information related to the causes of serious injuries and fatalities. The study briefly described the conditions and circumstances present at the time of accidents. The authors contended that while other studies have focused on the managerial climate associated with the accidents, they had failed to examine the actual field circumstances at the time of accident.

The study suggested the further desegregation of the five classes of accident used by OSHA:

- falls
- struck-by
- caught in/between
- electric shocks
- others

The study demonstrated how use of more detailed codification of the accidents, using OSHA data. The authors concluded that more detailed information can help to focus the preventive programs.

Overall, 33 per cent of the construction fatalities were caused by falls, 22 per cent were struck-by and 17 per cent by electrocution (OSHA 1990). Tables in the paper gives the revised codes of accident causation proposed by the authors, relate the major events types with occupation types and provide secondary factors of construction worker fatalities. Use of the revised codes demonstrate that 99 per cent of the falls were falls from elevation, that electrocution is largely due to contact with overhead cables and that only 7 per cent of the struck-by accidents involved material that was not falling. 67 per cent of the falls involved carpenters.

It was concluded that the causes of construction accidents can be characterised in greater detail with a minimum amount of effort and that use of such information can make the preventive program more effective. The study emphasised the importance of analysis of accident as the main source of understanding safety issues. The implications are that even the most representative opinion survey may mislead the researchers about the key factors involved in the accidents; the researchers should rely on accident analysis to understand accidents.

Hinze (1996) reported that since 1971, the fatality incidence rate in the construction industry has declined considerably. The most significant changes were realised in the 1970s, but improvements still occurred in the 1980s. Many factors have contributed to the improvement in safety performance including safety regulations, health care costs, litigation proliferation, and criminal prosecutions in wrongful death cases. Despite improvements, the construction industry has a dismal record when compared to all other industries combined. Studies of the trends in construction fatality statistics in the 1990s must take into account the change in reporting fatalities made by the National Safety Council. The National Safety Council has adopted data generated by the Census of Fatal Occupational Injuries since 1992.

2.2 Accident prevention

Jannadi (1996) conducted a sample survey of 86 safety officers and 173 workers from the top 200 construction companies in the UK to identify the key factors in accident prevention. Unlike many other studies the opinion of workers as well as safety officials was also considered; more conventionally, the focus remained on large construction companies.

The six most important factors were:

1 Maintaining safe work conditions
2 Establishing safety training
3 Safety education to promote good safety habits amongst workers and supervisors
4 Effective control of the main contractors on site
5 Maintaining close supervision of all work
6 Assigning safety responsibility to all levels of management and workers

Another study (Samuelson 1977) focusing on the middle level management found that:

- Management attitudes have more influence on safety than the foreman or peer groups.
- Workers work more safely for a supervisor who respects his men and their contribution.
- Better co-ordination improves safety.
- Work on piece rate basis rather than a fixed hourly basis increase the probability of accidents.

The study did *not* imply that middle level management was the only key factor, and indicated the findings need to be considered in conjunction with other studies.

Levit and Parker (1976) explored the role of top management in safety reduction. They found the key factors associated with success in safety were:

- Company manager's awareness.
- Safety performance used as a basis of superintendent's evaluation.

- Top management pointedly talking about safety during site visits.
- The consideration of lost-time in the award of incentives to the workers has no effect on safety.
- Management insistence of detailed work plan improves safety.

Jaselskis et al (1996) conducted quantitative and qualitative analysis of data related to companies and projects in the US to identify the factors considered to be important for a good level of safety. The performance indicators included; OSHA (Occupational Safety and Health Administration) recordable incidence rates, lost time, severity rates and the experience modification rate (EMR). EMR is calculated by taking the ratio between the dollar amount of adjusted actual claims filed to the dollar amount of expected claims for a particular type of construction, and is a three-year running average starting one year prior to the last full year (The Worker 1991). A company's EMR is a significant indicator because it reflects the cost a contractor pays for worker's compensation, and compares it with a norm for the type of work undertaken. Worker's compensation is directly related to safety performance due to claims against accidents. A qualitative measure of outstanding, average and below average project performance was also used.

The study recommended steps to lower EMR. These recommendations included:

- Increase time devoted to safety by 40 per cent.
- Provide greater details in safety programs.
- Increase the number of safety meetings. There should be at least 15 contact hours annually
- Consider delegating worker's compensation to a third party to avoid distraction of safety personnel.
- Orientation of new foreman on safety issues.
- Consider implementing alcohol and substance abuse testing program.

The study also recommends steps to achieve outstanding safety performance. These include:

- Strengthen upper management attitude towards the importance of safety.
- Reduce project-management-team turnover.
- Ensure field safety representatives spend 30-40 per cent time on safety issue.
- Increase the number of formal safety meetings with supervisors and speciality contractors to once a week.
- Increase the number of informal safety inspections to 4 per week.
- Reduce the amount of money fined for poor safety performance of workers.

Both the EMR and OSHA reportable incidence rate were found useful in evaluating a company's safety performance over years. The study confirms similar findings by Levitt and Samuelson (1987) on the value of EMR as an indicator, as it reflects actual costs paid for worker's compensation.

Zimolong (1985) investigated the motivation for safe behaviour as a function of risk estimation. It was found that workers were more likely to underestimate high risk situations if they had worked over a long period of time with these hazards. It was proposed that programs must be put into place to instruct employees about the actual hazards in order to reduce the discrepancies

between subject risk estimates and objective risks. The study highlighted the importance of comparing perceived and actual risks. However, the study did not answer the question as to why long work experience causes an underestimation of the risks or what determines the workers' perception of the risks.

Hinze and Pannullo (1978) found that increased job control improved safety performance. Injuries tended to be lower for projects in close proximity to the home office which was primarily due to more frequent visits by top management. A longer duration of employment also improves a worker's safety performance.

Hinze and Harrision (1981) identified safety program practices in large companies which resulted in a reduced injury rate. They identified the following key factors in safety:

- Field safety representatives hired by the corporate safety director.
- Field safety directors trained their subordinates.
- The safety director reports to the vice-president or the president of the company.
- New workers received formal safety orientation.
- Safety awards were given to the workers and the foreman.

This was followed by another study (Hinze and Rabound 1988) which identified appropriate means of achieving or maintaining an acceptable safety performance. The key factors included top management support which endorsed employing a full-time company safety officer. Regular safety meetings and performance monitoring undertaken for supervisors is also required. As job pressures affect the safety performance more attention should be given to better scheduling of works and discussion of safety issues in co-ordination meetings.

Hinze and Figone (1988a and 1888b) investigated the influence of the general contractor on speciality contractors for small, medium and large-scale projects. In additional to the safety factors discussed above they found the following additional factors improved safety with sub-contractors:

- Companies that negotiated a majority of prime contracts were safer.
- Smaller projects, projects with fewer speciality contractors and negotiated contracts resulted in fewer accidents.
- Daily inspections and good housekeeping.
- Less schedule pressure.
- Involvement of speciality contractors in meetings with owners/clients.
- Project schedules produced with on site departments.

Liska et al. (1993) introduced the concept of zero accident techniques to reduce the possibility of accidents. These techniques included:

1. Safety planning including goals, personnel, policies and procedures, fire protection programs and safety budgets.
2. Safety training and orientations.
3. Safety incentives.
4. Alcohol and substance abuse programs.
5. Accident and near-miss investigations.

6. Record keeping and follow-up.
7. Regular safety meetings.
8. Personal protective equipment employed.

Hislop (1991) recommended that the safety program, which could complement Liska's techniques, should include:

- A comprehensive safety policy statement.
- A review of constructability.
- Reliable contractor screening.
- Pre-construction meetings (safety review).
- Inspection.
- Good housekeeping.

A training manual prepared by the ILO (1987) discussed safety on site. It attributed the high rate of construction accidents to:

- the high proportion of small firms and of self-employed workers;
- the variety and comparatively short life of contraction sites;
- the high turnover of workers;
- the large proportion of seasonal and migrant workers;
- various trades and occupations.

The study identifies a need for a written safety policy with health and safety standards. This policy should address training issues, safe methods for handling hazardous operations, flow of information related to health and safety, roles and responsibilities, setting up of a safety committee and selection of subcontractors. It should also take into account the ILO international agreements; Safety and Health in Construction Convention (167) and its accompanying recommendation (No 175)

The manual highlights that a badly planned and untidy site is the underlying cause of many accidents. It outlines problems that should be taken into account when undertaking excavations near underground cables, work in the confined spaces and work carried out using scaffolding. Planning for vehicular movements and order of work is also highlighted as important.

Blackmon and Gramopadhye (1995) focusing on improvements in effectiveness of alarms systems in vehicles used in construction sites highlighted the problems associated with noise levels that confuse signals and communications. However, the study concluded that changing unsafe behaviour is also crucial for improving safety.

The UK Health and Safety Executive (1996) report that the noise pollution is often ignored but a serious risk to the worker and people around site.

The HSE manual entitled "Health and Safety in Construction" (1996) reported that site organisation is important. The site should be provided with facilities for washing, drinking water, changing and rest areas. It should also be properly lit with a boundary wall and site rules that include emergency procedures, for example, in the event of fire.

Many hazards are perceived to be an inevitable part of the job, resulting in no action being taken and the rate of accidents remaining high. The risks need to be controlled where they cannot avoided. As falls are the largest causes of accidents, basic precautions should be undertaken before working at height. The work platform should be secure and adequate for the loads to be carried, the supporting ground firm, guard rails should be provided and appropriate harnesses and lines should be available.

The main causes of death and injuries during excavation involved:

- Collapse of the sides.
- Material falling onto people in the excavation.
- People and vehicles falling into the excavation.
- Undermining nearby excavation.
- Striking underground services.

Working in confined spaces is dangerous due to:

- Gas build-up in sewers and manholes and pits connected to them.
- Gas leaking into trenches and pits in contaminated lands.
- Oxygen consumption by rust inside tanks and vessels.
- Liquid and slurries that can suddenly fill the space or release gases into it.
- Chemical reactions between some soils and air causing oxygen depletion or production of carbon dioxide.

Adequate ventilation should be ensured, and mechanical ventilation may be necessary. Entrance to the space should be large enough to allow trained workers wearing the necessary equipment to enter.

Tulacz (1994) argued that safety could save money. He reported the case of a steel erector who implemented a unique safety programme that used incentives and accountability. The programme developed after a tragic fall which caused a worker's death. The profit-sharing incentives are an indirect way of instilling in the workers the discipline needed in enforcing safety measures. While entailing substantial investment, the safety program proved cost-efficient in the long run. An official noted a drop in the workers' compensation modifier as a direct result of the program.

Soedarmono et al (1996) suggested that as falls are the dominant cause of construction fatalities, a computer model for construction workers to avoid falls during hazardous construction operations would be beneficial. The model outlined in the paper intends to provide construction workers with a tool for ‘on the job’ training on simulated construction platforms. It includes working platforms from which falls frequently occur, such as floor openings, floor edges, wall openings, tops of walls, and ladders. These working platforms are represented as 3-D objects from which trainees can retrieve on-line information. To obtain the information, the trainee needs to approach a given working platform, such as a floor edge, whereupon a warning consisting of the required safety standards is displayed. With this method, the trainee can learn how to provide a safe working environment while at the same time experiencing participation in a real construction site. This model has been successfully constructed and tested for its feasibility and potential use in promoting construction safety.

The paper indicated that there could be many kinds of training in relation to safety. With the availability of information technology the trainee should not be restricted to paper based media. Simulation can play an important role particularly when the trainees are not literate.

2.3 Stakeholders in safety prevention

Gambatese et al (1997) claim that the design professional is not educated to handle safety at design level. As a result they try to avoid taking part in safety issues, as they fear that they would increase their liability by doing so. The paper brought out both the distinction between the roles of the owner and the contractor in safety programmes, and the designers' lack of concern about it. The issue of attitude towards safety was also raised. After reviewing literature and interviewing construction related people, the authors developed a database consisting of 400 design suggestions for safety at design stage. Classifications for design discipline, project components, project systems and construction site hazards were developed. The database could be adopted and used in relation to developing countries. They also make three suggestions for design and implementation that they believe would reduce the risk of accidents.

1. Minimise the number of offsets in a building plan, and make the offsets a consistent size and as large as possible. This will prevent a fall hazard by simplifying the work area for construction workers.

2. Design underground utilities to be placed using trenchless technologies which will eliminate the safety hazards associated with trenching, especially around roads and pedestrian traffic surfaces

3. Do not allow schedules with sustained overtime as workers will not be alert if overtime is maintained over a long period.

Kilbert and Coble (1995) discuss the relationship and overlap between safety and environmental issues. The overlap has implications for the roles and responsibilities of the many organisations involved. Although the paper was based on experience in the USA, the problems are generic in nature. The authors suggested combining safety and environment procedures and merging of OSHA and EPA. The study assumes that a single agency dealing with a well-defined area will be more effective than many agencies with overlapping issues and responsibilities. The authors also urge that the contractor should be provided with a bid package that clearly identifies the responsibilities of contractor and owner for safety and environment requirements. It was recommended that legal duties should be explicitly communicated to the potential bidder at the time of invitation to bid. The implication is that in many cases the contractors are not aware of their implicit legal responsibilities in relation to the health and safety issues.

Young, S. (1996) emphasised the role of site engineers to improve safety at sites. To achieve fully common project goals of greater value, lower costs and reduced risk, engineers on the front line must take the lead in implementing innovative, yet pragmatic approaches that strategically integrate safety concerns into the project management process.

While significant improvements in safety performance have been made in the past few decades, one party within the project team, the designer, has not been directly involved in the safety effort. Gambatese et al (1997) also cited a study conducted by the Construction Industry

Institute (CII), in which best design practices to minimise or eliminate construction site hazards have been tabulated. These design suggestions have been incorporated into a computer program, entitled 'Design For Construction Safety ToolBox' that assists designers in recognising project-specific hazards and implementing design suggestions. This computer program links the design and construction phases to improve construction worker safety. Although the toolbox was designed for developed counties, it may be a useful tool for issues related to some of the design aspects in developing counties.

Sweeney (1997) pointed out that the future of health and safety in the construction industry depends on a collaboration of many parties, including labour, industry, academia, private organisations and government. The National Institute for Occupational Safety and Health (NIOSH) is the single federal organisation mandated by US Congress to conduct research to protect the health and safety of workers. Its successes through its partnerships over the past five years demonstrate that H&S is an important element of the construction job.

Samuelson and Leveitt (1982) provide owners' guidelines for selecting safe contractors and monitoring safety performance. The useful strategies which have an impact on contractor's safety were:

- use of short-term permits to regulate hazardous operation;
- stressing safety during periodic visits;
- maintenance of safety records;
- incorporating detailed job-specific safety requirements in the specification;
- periodic inspections;
- awards for safe practices; and
- considering safety as a criterion in pre-selection of contractors for bids.

Construction Industry Training Board (CITB) prepared a construction site safety course (1998) aimed at the industry in the UK. The course assumes the availability of a legislative and regulatory framework, and that the relevant institutions exist to train the workers and monitor the safety at workplaces.

2.4 Institutional

Tajman and de Veen (1998) reported that creating opportunities for many people to participate in construction work involves certain risks. There is little relevant enforceable legislation in developing countries, and little attention is paid to social security and work-related insurance. Contract documents occasionally cover some requirements, but further relevant safety requirements can be made through tendering and contract documents. Safety needs to be costed and paid for by the employer either directly or indirectly.

Simple requirements like those for first aid kit and the provision of safe water can be enforced. The authors described a survey in India where although requirements were reported to have been fulfilled, inspection revealed that hardly any sites met requirements. The facilities provided were more for presentation than for actual use.

The study indicated that the written legal and contractual requirements are not the only determinants of safety on a construction site. The perceptions of people about safety requirements are a key factor in addressing the issues. Monitoring and advocacy could be the

tools to ensure that the minimum health and safety requirements are met. Safety may cost money to the client but it is worth paying this financial cost to avert the economical or social losses associated with lack of health and safety

The Construction Industry Advisory Committee (1987) reported that there have been some achievements in prescribing preventive measures and legislation. However, there is a limit to the achievements that can be achieved through negative regulations. Contractual arrangements are important in discharging health and safety responsibilities.

It was suggested that the safety records and relevant information should be considered at the time of short listing of the contractors. Contractors should be asked to submit accident records with follow-up actions and safety policy. Care should be taken in the evaluation of tenders to ensure that the contractor is not achieving competitiveness by reducing cost for health and safety. The use of contract documents as a means of communicating and enforcing health and safety requirements is again emphasised; however, the onus remains on the contractor. The study did not propose any suggestion as to how the Client and the Engineer can play an effective role in promoting the health and safety performance.

The main contractor would be responsible for practices related to health and safety of the sub-contractors. The contractors should be provided with access to the internal and external sources of information related to health and safety. In conditions of unstable economics and high unemployment or under-employment, labourers are likely to demand only the minimum wages and not insist upon safety and security packages. Safety may not necessarily be demand driven, as the worker and even the professional does not enjoy an equal bargaining position.

Labour (1998) described how the construction industry developed from the master builder system into design and construction specialities, and how these have influenced perspectives on responsibility. He raised issues regarding the liability of the designers in the traditional design-bid-build system. It was argued that designers should contribute more in achieving the safety objectives. The construction industry had 15 fatalities per 1000 workers in 1996 as compared to 4 per 1000 workers in all other industries combined. . The frequency of disabling injuries was 5300 per 100,000 as compared to 3100 per 100,000. The records of the last 45 years confirm the trend that the construction industry has very high fatality and injury rates.

Currently the constructor bears the responsibility for safety, reflected in his control over the site. However, as the designer affects the configuration and work process, s/he should be involved in the safety consideration. Traditionally, unless explicitly written in the contract, a designer participating in the design-bid-build arrangement is not responsible for overseeing the construction work safety. On the other hand, by directing the construction work sequence to some extent, the designer assumes partial responsibility for the construction efforts. The designers and the architects use current codes and specifications for the end user; in fact, the construction workers should also be viewed as "users" but of a different kind. There is therefore a need to design for the safety of construction workers.

There are some general lessons to be learned that could be applied to the context of developing countries. The issue of liabilities of parties other than the contractor is an interesting one as the issue can be scaled up to ask whether the donors or financiers of the development

projects are also responsible for safety hazards, especially if they are involved in the approval process.

The International Labour Office sponsored a regional workshop on the assessment of relevant policies and programs in construction (1991). The proceedings provide an overview of the Asian region state of legislation and regulations. ILO convention 167 still needs to be ratified in many countries, especially where there are no special provisions for construction workers' safety. In some countries the law is available but not enforced and proper records are not maintained, as there is a lack of a regulatory framework.

The International Labour Office Training Manual on Safety, Health and Welfare on Construction Sites (1990) consists of some useful suggestions in the form of 'Points to remember'. Different stages of construction are discussed with reference to the causes of accidents and safety requirements including sections on welfare and safety equipment. The discussion is followed by a checklist, ILO conventions and proposed guidelines.

The document is limited to the construction site only. It can be seen as a useful document for specification purposes. In many cases the document may appear to represent something of a "wish list" with some of the suggestions best taken as long terms targets. There seems to be a less realistic linkage between what is on the ground and what could be done to achieve the desired level of safety in construction. The document is not based on any empirical studies.

Sweeney (1997) pointed out that the state of construction safety as evaluated on the basis of compensation cost is not satisfactorily. In the USA 5-6 per cent of the workforce is employed by the construction industry but it accounted for more than 15 per cent of worker's compensation costs.

In a developing country context the financial compensation and claims may not be a realistic criterion for evaluating performance of industry for health and safety. Firstly, there are no reliable information systems to refute or corroborate claims. Secondly, there is not a strong culture of compensation, insurance or claims in many developing countries. Finally, the rights of workers are either non existent, not communicated or not enforced. However, the health and safety cost in developing countries remains significant, as the economic and social cost to workers and society due to lack of health and safety is significant.

Koehn et al (1995) discussed the issues of safety in developing countries addressing professional and bureaucratic problems. It was argued that the procedures should be developed especially for work in extreme heat. Koehn indicated that injuries are often not reported but an informal cash compensation or treatment is provided in some cases. The normal compensation for death was found to be equivalent to three months' pay.

It was reported that in Taiwan, the responsibility for claims resulting from accidents is jointly shared by the contractor and the employer. The component of the systems adopted by some in Taiwan comprises of:

- Planning and rules development.
- Problem identification.
- Safety inspection and reports.

- Analysis and investigation.
- Error correction and training.

The role of employee involvement in safety programs and self-inspection by the contractor was emphasised.

Koehn and Regmi (1991) reported that construction in India is more labour intensive than in the industrialised world, involving 2.5 to 10 times more workers per activity. Many large contractors only have a safety policy "on paper" which is not enforced. The regulations are also not enforced, although some improvements have been made in legislation.

Different occupations have attracted people of different regions. For example, excavators often come from Andhra Pradesh, concrete labourers from Kartnataka, carpenters from Rajasthan and masons from Uttar Pradesh. The findings are in line with the personal experience of this report's author in Pakista where 'Pathans' specialise in excavation, 'Rangahrs' are the masons, villagers from a certain part of Punjab undertake high tension power line works and certain groups of women are involved in only road construction.

This reinforces the feeling of many practitioners that so-called 'unskilled tasks' are in reality specialist tasks, and in some cases monopolies. The specialisation and geographical concentration of professionals has very interesting implications for health and safety considerations particularly for occupational health aspects.

3. Further Work / Research

The literature review has shown that there are very little data available on the safety on construction sites in developing countries. Although it is reasonable to assume that the type and level of accidents are similar to those in the UK where data exists, surveys should be undertaken to confirm a baseline for the level of accidents in developing countries. These surveys would aim to give the following information:

- confirm the types of injury and fatality are similar to UK statistics;
- the level of accidents, i.e. the percentage of workers injured each year / probability of injury;
- the type of work and trade which is most at risk of accidents;
- the level of safety training / awareness that exists in country; and
- the relationship between hazard perception and safety performance of the workforce.

Regardless of the safety programmes that are implemented, accidents will still occur. Contractors will often have insurance against claims made by the client, through the contract, but the level of insurance against injury claims from employees is unclear. Investigations should be carried out to determine the safety nets that exist when workers are injured and how effective they are at protecting or supporting the workers.

The majority of small project construction work in developing countries will be carried out by labour-based methods which utilise a large number of handtools. Research has shown that poor quality handtools not only increase the time taken to complete a task but also the fatigue of the worker (Dennis 1999). Poor quality handtools are more likely to cause injuries to the worker. Further work should be undertaken to promote the benefits of improved quality of handtools to justify their increased cost.

Contract documents outline the responsibilities, including safety, of all the parties involved in the project. Where local or community contract documents are used for a project they should be reviewed to ensure that the safety risks and responsibilities of all the parties are clearly stated. Where necessary amendments or additions should be made to ensure responsibilities are realistic and achievable in order that they will be adhered to rather than ignored.

Ultimately, there are two important ways to reduce construction accidents. The first priorities will be to promote awareness and enforcement of realistic safety legislation. Secondly, there is a need to encourage hazard awareness training of workers and employers on construction projects. As an interim measure, DFID may consider developing a construction safety policy for its projects. Safety will not be improved unless there is a demand or incentive provided to the contractors. As workers frequently feel that their jobs are too insecure to make large demands on their employers, the initiative for improved safety must come form the client. As DFID will ‘hold the purse strings’ on many projects it will be in a suitable position to encourage or demand improved safety procedures on these projects, in line with its safety policy or guidelines.

4. List of documents reviewed

- Accidents and Occupational Diseases (Notification) Chapter 330 (1956) of The Laws (Parts 1 & 2), Tanzania.
- Ahlgren, A., Burman, B., Lowing, H. and Skoldberg, T. (1989) Accidents in Construction Industry, Bygghalsan, Stockholm, Sweden.
- Axelsson, P. O. and Nilsson, L. (1987) Hanging in There, Report TRITA-AOG-0041, Royal Institute of Technology, Stockholm, Sweden.
- Blackmon, R.B. and Gramopadhye, A.K. (1995) Improving Construction Safety by Providing Positive Feedback on Back-up Alarm, Journal of Construction Engineering and Management, ASCE, Vol.121, No. 2.
- Conditions of Contract for Works of Civil Engineering Construction 4th Edition(1987) Parts 1 and 2 with Amendments (1996), Federation Internationale Des Ingenieurs-Conseils, Switzerland.
- Conditions of Contract Public Works Department, Nagar Mahapalika Lucknow, India
- Construction Industry Advisory Committee (1987) Managing Health and Safety in Construction: Principles and Application to Main Contractor/Subcontractor Projects, HMSO, UK.
- Construction Industry Training Board (1988) Construction Site Safety Course, Construction Industry Training Board, UK.
- Cotton, A.P., Sohail, M. and Tayler, W.K. (1998) Community Initiatives in Urban Infrastructure, WEDC, Loughborough University.
- Dedobbeleer, N. and German, P. (1987) Safety Practices in Construction Industry, Journal of Occupational Medicine, Vol.29(11), pp.863-868.
- Dennis (1999) Handtools for Labour-Based Roadwork; Guidelines for Selection and Procurement. Institute of Development Engineering, Loughborough University, UK
- European Construction Institute (1995) Total project Management of Construction Safety, Health and Environment, Thomas Telford, UK.
- Everitt, J.G. and Thompson, W.S.(1995) Experience Modification Rating for Worker's Compensation Insurance, Journal of Construction Engineering and Management, ASCE, 121(1), pp.66-79.
- Form and Conditions of Contract Used in Dar-es-Salaam City Commission.
- Form for Performance Bond, National Insurance Corporation of Tanzania.
- Form for Piece Work agreement Not Exceeding 1.5 million, Dar-es-Salaam City Commission.

- Form for Tender Bond, National Insurance Corporation of Tanzania.
- Gajara, V.S. (1992) Construction Management, Pragati Prakashan, Bombay, India.
- Gambatese, J.A., Hinze, J.W. and Haas, C.T. (1997) Tool to design for construction worker safety, Journal of Architectural Engineering, ASCE, Vol.3, No.1.
- Gambatese, J.A.(1998) Libility in desighning for constrcution workers safety, Journal of Architectural Engineering, ASCE, Vol.4, No.3, 107-112
- Gambatese, J.A., Hinze, J.W. and Haas, C.T. (1997). Tool to design for construction worker safety, Journal of Architectural Engineering, Mar 1997, Vol.3, No.1, pp.32-41
- Guidance on the Collection and Use of Accident Information in the Construction Industry, HMSO, UK.
- Health and Safety Executive (1985), Deadly Maintenance Plant and Machinery - A study of Fatal Accidents at Work, HMSO, UK
- Health and Safety Executive (1988) Deadly Maintenance - A Study of Fatal Accidents at Work, HMSO, UK.
- Health and Safety Executive (1995) Construction (Design and Management) Regulations 1994: The Role of the Client, HSE Information Sheet, Construction Sheet No 39, Health and Safety Executive, UK.
- Health and Safety Executive (1995) Construction (Design and Management) Regulations 1994: The Role of the Planning Supervisor, HSE Information Sheet, Construction Sheet No. 40, Health and Safety Executive, UK.
- Health and Safety Executive (1995) Construction (Design and Management) Regulations 1994: The Role of the Designer, HSE Information Sheet, Construction Sheet No. 41, Health and Safety Executive, UK.
- Health and Safety Executive (1995) Construction (Design and Management) Regulations 1994: The Pre-tender Stage Health and Safety Plan, HSE Information Sheet, Construction Sheet No. 42, Health and Safety Executive, UK.
- Health and Safety Executive (1995) Construction (Design and Management) Regulations 1994: The Health and Safety Plan during the Construction Phase, HSE Information Sheet, Construction Sheet No. 43, Health and Safety Executive, UK.
- Health and Safety Executive (1995) Establishing Exclusion Zones When Using Explosives in Demolition, HSE Information Sheet, Construction Sheet No. 45, Health and Safety Executive, UK.
- Health and Safety Executive (1996) Cement, HSE Information Sheet, Construction Information Sheet No. 26, Health and Safety Executive, UK.
- Health and Safety Executive (1996) Health and Safety in Construction, UK.

- Health and Safety Executive (1996) Noise in Construction - Further Guidance on the Noise at Work Regulation 1989, Health and Safety Executive, UK.
- Health and Safety Executive (1997) Construction Fire Safety, HSE Information Sheet, Construction Information Sheet No. 41, Health and Safety Executive, UK.
- Health and Safety Executive (1997) Construction Health and Safety Checklist, HSE Information Sheet, Construction Information Sheet No. 17, Health and Safety Executive, UK.
- Health and Safety Executive (1997) Personal Protective Equipment (PPE) Safety Helmets, HSE Information Sheet, Construction Information Sheet No. 50, Health and Safety Executive, UK.
- Health and Safety Executive (1997) Provision of Welfare Facilities at Transient Construction Sites, HSE Information Sheet, Construction Sheet No. 46, Health and Safety Executive, UK.
- Health and Safety Executive (1997) Safety in Executive, HSE Information Sheet, Construction Information Sheet No. 8, Health and Safety Executive, UK.
- Health and Safety Executive (1998) Chemical Cleaners, HSE Information Sheet, Construction Information Sheet No. 24, Health and Safety Executive, UK.
- Health and Safety Executive (1998) Provision of Welfare Facilities at Fixed Construction Sites, HSE Information Sheet, Construction Information Sheet No. 18, Health and Safety Executive, UK.
- Health and Safety Executive (1998) Solvents, HSE Information Sheet, Construction Information Sheet No. 27, Health and Safety Executive, UK.
- Health and Safety Executive, (1988) Health and Safety Statistics 1985-86, HMSO, London, UK.
- Heinze, J. and Wiegand, F. (1992) Role of Designers in Construction Worker Safety, Journal of Construction Engineering and Management, ASCE, 118 (4), pp.677-684.
- Helander, M.G.(1991) Safety Hazards and Motivation for Safe Work in the Construction Industry, International Journal of Industrial Ergonomics, Nov. 1991, Vol.8, No.3, pp.205-223.
- Hickling, J. (1985) An Investigation on Construction Site as Factors Affecting the Acceptability and Wear of Safety Helmets, University of Technology, Institute of Consumer Ergonomics, Loughborough, UK.
- Hinze, J. and Figone, L.A. (1988a) Subcontractor Safety as Influenced by General Contractors on Small and Medium Sized Projects, Source Document 38, Construction Industry Institute, University of Washington, Seattle, Wash.
- Hinze, J. and Figone, L.A. (1988b) Subcontractor Safety as Influenced by General Contractors on Large Projects, Source Document 39, Construction Industry Institute, University of Washington, Seattle, Wash.

- Hinze, J. and Gordon, F. (1979) Supervisor-worker Relationship and Injury Rate, Journal of Construction Division, ASCE, 105(3), pp.253-261.
- Hinze, J. and Harrison, C. (1981) Safety Programs in Large Construction Firms, Journal of Construction Division, ASCE, 107(3), pp.455-467.
- Hinze, J. and Pannulu, J. (1978) Safety : Function of Job Control, Journal of Construction Division, ASCE, 104(2), pp.241-249.
- Hinze, J. and Rabound, P. (1988) Safety on Large Building Construction Projects, Journal of Construction Engineering and Management, ASCE, 114(2), pp.286-293.
- Hinze, J., Pedersen, C. and Fredley, J. (1998) Identifying Root Causes of Construction Injuries, Journal of Construction Engineering and Management, ASCE, Vol.124, No.1.
- Hinze_J (1996) Construction Safety Record since 1971, Proceedings ASCE National Convention, 1996, pp.113-120, ASCE, New York, NY, USA.
- Hislop, R.D. (1991) A Construction Safety Program, Profl. Safety, 36 (9), pp.14-20.
- ICE Conditions of Contract Minor Works 2nd Edition (1995), Thomas Telford, UK.
- Improving Construction Safety Performance (1988) Reprint Rep. A-3, Construction Industry Institute, Austin, Texas.
- International Labour Office (1987), Safety, Health and Welfare on Construction Sites. A Training Manual, International Labour Office, Geneva.
- International Labour Office (1988) Safety and Health in Construction Convention, No. 167, International Labour Office, Geneva.
- International Labour Office (1990)Training Manual on Safety, Health and Welfare on Construction Sites, ILO/UNDP Project RAS/86/072 Promotion of Safety, Health and Welfare in the Construction Industry, ILO.
- International Labour Office (1991). Regional Workshop on the Assessment of Relevant Policies and Programs in Construction (Phuket, Thailand, 15-17 April 1991) Proceedings and Country Papers (1991), ILO/UNDP Project RAS/86/072 Promotion of Safety, Health and Welfare in the Construction Industry, International Labour Office.
- Jannadi, M. O. (1996) Factors Affecting the Safety of the Construction Industry, Building Research and Information, Vol.21, No.2, UK.
- Jaselskis, E.J., Anderson, S.D., Russell, J.S.(1996) Strategies for Achieving Excellence in Construction Safety Performance, Journal of Construction Engineering and Management, Vol.122, No.1, pp.61-70, ASCE, New York, NY, USA
- Kilbert C.J, Coble R.J (1995) Integrating Safety and Environmental Regulation of Construction Safety. Journal of Construction Engineering and Management, Vol.121, No.1, pp.95-99, ASCE, New York, NY, USA

- Koehn E. and Surabhi, M.R. (1996) Future Changes/Improvements in Construction Safety, Proceedings ASCE National Convention, 1996, pp.121-128, ASCE, New York, NY, USA
- Koehn, E. and Regmi, D.C. (1991) Labour Cost Calculations in International Construction, AACE Trans, Seattle, Wash, pp. 0.2.1-0.2.5
- Koehn, E., Kothari, R.K. and Pan, C. (1995) Safety in Developing Countries: Professional and Bureaucratic Problems, Journal of Engineering and Management, ASCE, New York, Vol.121, No. 3, pp.261-265. New York
- Labour, J.A.(1998) Liability in Designing for Construction Workers Safety, Journal of Architectural Engineering, ASCE, Vol.4, No.3, pp107-112
- Labour, J.A., Hinze, J.W. and Haas, C.T. (1997) Tool to Design for Construction Worker Safety, Journal of Architectural Engineering, ASCE, Vol.3, No.1. pp.32-41
- Leveitt, R.E. and Samuelson, N.M. (1987) Construction Safety Management, McGraw-Hill, New York, NY.
- Liska, R.W., Goodle, D. and Sen, R. (1993) Zero Accident Techniques, Source Document 86, Construction Industry Institute, Austin, Texas.
- National Safety Council (1997) Accident Facts, Itasca, IL.
- OsamaJannadi, M. (1996) Factors Affecting the Safety of the Construction Industry, Building Research and Information, Vol.24, No.2, Chapman & Hall Ltd, London, England.
- OSHA, Analysis of Construction Facilities - OSHA Database 1985-1989 (1990) U.S. Dept. of Labour, Occupational Safety and Health Administration (OSHA), Washington, D.C.
- Samuelson, N.M and. Leveitt, R.E. (1982) Owner's Guidelines for Selecting Safe Contractors, Journal of the Construction Divisions, ASCE, 108: pp.617-623.
- Soedarmono, D.R., Hadipriono, F.C. and Larew, R.E. (1996) Using Virtual Reality to Avoid Construction Falls, Computing in Civil Engineering (New York), 1996, pp.899-905.
- Sohail, M. (1997) An Investigation into the Procurement of Urban Infrastructure in Developing Countries, PhD, Loughborough University
- Standard Conditions for Contractors' All Risks Policy, National Insurance Corporation of Tanzania Limited.
- Standard Conditions for Erection All Risks Policy, National Insurance Corporation of Tanzania.
- Suazo, G.A.R. and Jaselskis, E.J. (1993) Comparison of Construction Safety Dodes in United States and Honduras, Journal of Construction Engineering and Management, Sept. 1993, Vol.119, No.3, pp.560-572.

- Sweeney, M.H.(1997) Moving Construction Safety and Health into the 21st Century, ASCE Construction Congress Proceedings, 1997, pp.40-45, ASCE, New York, NY, USA.
- Tajman, D. and de Veen, J. (1998) Employment-Intensive Infrastructure Programs: Labour Policies and Practices, Development Policies Department , International Labour Offices, Geneva.
- The Occupational Safety and Health Administration (OSHA) Database 1985-1990 (1990) Analysis of Construction Fatalities, U.S Department of Labour, Occupational Safety and Health Administration, Washington, D.C.
- The Short Contract (Engineering and Construction) (1997), A New Engineering Contract Document, Thomas Telford, UK.
- The United Republic of Tanzania (1991) Standard Form of Contract For Piece Works- Civil Engineering Works, Contracts Control Unit, Ministry of Works.
- Training and Educating Workers and Supervisors.
- Tulacz G.J (1994) L.P.R. Construction: Safety Pays, ENR (Engineering News-Record), Sept 26 1994, Vol.233, No.13, McGraw-Hill Inc, New York, NY, USA
- Workmen's Compensation Act, 1923 Together with Workmen's Compensation Rules, 1924, Workmen's Compensation (Transfer of Money) Rules, 1935; Workmen's Compensation Returns along with Short Notes, Seventeenth Edition 1995, Eastern Book Company, Lucknow, India
- Workmen's Compensation Act, CAP 263 (1958) of the Law (Revised) (Principal Legislation).
- Young, S. (1996) Construction Safety: A Vision for the Future, Journal of Management in Engineering, No.4, pp.33-36, ASCE, New York, NY, USA
- Zimolong, B. (1985) Hazard Perception and Risk Estimation in Accident Causation. In : R.E.Eberts and C.G. Ernerts (Eds.), Trends in Ergonomics/ Human Factors 11. North-Holland, Amsterdam, The Netherlands, pp 463-470.